picked up a good sub-triangular wedge-shaped implement. Further search produced a second implement, a good trimmed flake, and a few simple flakes. The worked flints in the Hertford gravel are however so rare that the search for them is the most hopeless task conceivable. There is not more than one flake in 500 tons, not one implement in 5000 tons of gravel. The gravel from Ware is also brought to the east of London for ballast, and I happened last year to mention the fact of my discoveries to Mr. J. E. Greenhill, the Principal of a school near Hackney Downs. Mr. Greenhill at once not only searched himself, but set his pupils to look over the Ware gravel, then laid down in large quantities near Clapton, with the result that a large broken ovate implement was found and several flakes. I also found a large and heavy "slice" flake with numerous facets on its worked side in the same gravel. Mr. Greenhill's success caused me to look carefully over a similar lot of gravel from Ware, laid down near Victoria Park. In this I found a sub-triangular implement and three flakes. I have also found a large greatly abraded flake in the Amwell gravel at Amwell. Elsewhere in east and north-east London I have looked over thousands of tons of Hertford and Ware gravel without decisive result. A week or two ago, however, as my younger son was returning home through Finsbury Park, he picked up a good scraper-like implement in the gravel (presumably from Hertford), just thrown on to the road inside the park. On hearing of the discovery I at once went to Finsbury Park and looked carefully over all the recently thrown down material, but with no further result. I have visited the different pits at Hertford, Ware, and Amwell several times, but there is never enough gravel exposed (considering the extreme comparative rarity of the implements and flakes) to give one a chance of finding an implement. I have found in the pits several simple flakes, with the cone of percussion, and that is all. At what depth the implements occur in the gravel I do not know, but that implements really do come out of the high gravels overlooking Hertford and Ware I think there can be no doubt. Reference was made by me to these implements at the Anthropological Institute three years ago, when two or three specimens were exhibited by me.

WORTHINGTON G. SMITH

125, Grosvenor Road, Highbury, N.

Sound of the Aurora

WITH every respect for the ability and acuteness of the late Sir John Franklin and his companions, I do not think it conclusive, as Mr. Rouse seems to do, that because they heard no sounds "with the aurora borealis" (NATURE, vol. xxiii. p. 556), no sounds are produced by it.

All Indians, both on the shores of Hudson's Bay and near Bear Lake, and the Eskimos on many parts of the coast, assert positively that the bright, varying, flickering,[1] and rapidly-moving auroræ do produce sound. The senses of hearing and smelling in the Indian and Eskimo are far more acute than in the civilised man; and both sounds and smells which to the latter are not perceptible are perfectly so to the more sensitive auditory and olfactory organs of the savage.

The theory that "the attractive force of the aurora is increased within a certain limit as its rays proceed southward" is scarcely borne out by my experience.

When wintering at Fort Hope, Repulse Bay, in 1846-47 and 1853-54, lat. 66° 32′ N., the result of my observations was, as far as I can discover, exactly similar to that of Parry in 1824-25 at Port Bowen in lat. 73° 15′ N., 400 miles further north and fifty miles west of Fort Hope: at both no effect was produced on the magnetic needle.

At Repulse Bay, and it may have been the same at Port Bowen, the character of the aurora was perfectly different from that generally seen at Great Bear Lake, which acted so powerfully on the needle, the former being almost always of a uniform pale yellow or straw colour, with little rapid motion, whereas the latter was generally flashing, flickering, rapidly moving, and of diverse hues.

One peculiarity of the auroræ observed at Repulse Bay may be worthy of notice: they were chiefly seen to the magnetic south—that is south 62° east true—usually in the form of an arch rather low down—and I may add that in that direction at a distance of thirty or forty miles from our head-quarters a large extent of sea is kept open all winter by strong currents. The Eskimos of Repulse Bay do not say much about the aurora beyond expressing a belief that it is the spirits of their dead visiting each other in the heavens.

[1] I borrow this most appropriate term from Prof. Stokes, F.R.S., &c., of Cambridge.

It is probably a matter of little or no importance in a question of this kind, but Mr. Rouse has given the latitudes of the southern shores of Great Bear Lake from 90 to 200 miles too far north.

Fort Franklin, where Franklin made his chief observations, is situated in latitude 65° 12′ N. at the extreme south-west of Great Bear Lake, whereas Fort Confidence, where Sir J. Richardson and I made ours with like results, is at the extreme north-east of the lake in lat. 66° 54′ N., the stations being 150 miles distant from each other.

It is perhaps not being too sanguine to hope that in this period of marvellous discoveries, some instrument may be—if not already—invented, with the aid of which one may be able to decide the question satisfactorily as to whether the aurora in any form does or does not produce sound.

JOHN RAE

4, Addison Gardens, April 16

THE SCIENTIFIC PRINCIPLES INVOLVED IN ELECTRIC LIGHTING[1]

II.

Lectures III. and IV.

ALL machines for the conversion of mechanical work into electricity are founded on Faraday's great discovery of the induced current derived from the relative motion of a magnet and a coil of wire. They are either continuous-current or alternate-current machines. From the continuous-current machines of Pixii in 1832 and Saxton and Clarke in 1835 and 1836, we pass to Wheatstone's introduction in 1845 of electromagnets in place of permanent magnets to produce the magnetic field. In 1854 Werner Siemens and Halske introduced the Siemens armature, in which the coil is wound longitudinally in a groove. In 1854 Hjorth patented an improved magneto-electric battery, in which the currents induced in the revolving armature pass round the electromagnets and produce the magnetic field. This is the principle of the dynamo-electric machine, which was afterwards rediscovered by Siemens and by Wheatstone simultaneously in 1867, when on the same evening their two papers were presented to the Royal Society.

Then followed the Gramme armature, in which coils of wire are wound in sections all in the same direction round a ring; each section, when a current is flowing through it, may be regarded as an electro-magnet, and its principle of action is clear at once from the principles of Arago and from Lenz's laws for induced currents.

In dynamo-electric machines the external work in the electric are is proportional to the square of the current, and is also proportional to the number of turns of the armature per minute.

Any disturbance in the resistance of the arc reacts on the electro-magnet, altering the strength of the magnetic field, thereby increasing the disturbance; this is the great disadvantage of dynamo-electric machines as compared with magneto-electric machines, where the magnet is either a permanent magnet or is excited by means of a separate current. Wilde, in 1863, employed a separate continuous current machine to give a permanent magnetic field, and made the armature of the second machine to revolve in this magnetic field. In alternate-current machines there is no commutator for making the current continuous, but the currents from the coil are collected and sent through the external resistance in opposite directions for every half-turn of the armature. The Alliance magneto-electric machine was the first of these, which was converted by Holmes into a continuous-current machine, and was by him first used in 1858 to produce the electric light for lighthouse illumination. He afterwards again converted his machine into an alternate-

[1] By Prof. W Grylls Adams, F.R.S. Continued from p. 582.

current machine by removing the commutator, thereby producing a very effective machine.

All theoretical determinations of the efficiency of machines are complicated by the retardation of magnetisation of the magnets, which necessitates a change of position of the commutator or brushes in the direction of the rotation of the armature. The practical determinations of efficiency which have been made show that from 86 to 88 per cent. of the energy communicated to a dynamo-machine is converted into electrical energy, and that from 44 to about 50 per cent. of the total work may be converted into useful work in the external circuit. Among the more recent continuous current machines are the Brush and the Bürgin machines, which promise to give good results.

At intervals during the lecture the room was lighted by various electric lamps, the peculiarities of each of which were explained. The Brockie lamp, lent by the British Electric Light Company, and served by one of their Gramme machines; the Siemens pendulum-lamp lent by Dr. Siemens, and the Crompton lamp lent by Mr. Crompton, were each tried in turn, and attention was drawn to the Siemens' differential lamp, the Brush lamp, and other lamps and electric candles which were also exhibited.

The subject of the fourth Cantor lecture was the subdivision of the electric current and lighting by incandescence. Prof. Adams showed that objections raised to the electric light were similar to those which had been urged with regard to gas when it was first introduced. He then compared the energy of Grove's cells with the energy derived from a small Gramme machine, and showed how impracticable it was to attempt to do by means of batteries the work which can be done by such machines. He then explained how the same amount of energy might be spent in two classes of machines, those of low internal resistance and low electromotive force which send a strong current through small external resistance, or quantity machines, and those of high internal resistance and high electromotive force sending a smaller current through large external resistance, or tension-machines. For very high resistances the discharge of an induction-coil is taken, the action of which was compared to the action of the hydraulic ram. Prof. Adams proceeded to describe the Werdermann and the Joel lamps, and explained the kind of machine specially suited for such lamps, and regretted that it would not be possible to show them to the best advantage, or to give them a fair trial, because the machine actually in use at the speed at which it was running was not adapted for them. An electromotive force of 130 volts will send 50 webers through 10 lamps in series, and give an illumination of 320 candles in each lamp for an expenditure about 10 h.p. Taking Mr. A. Siemens' facts as to the cost, it appears that the electric light from the Joel lamp would be as cheap as gas at the rate of 2*s.* per 1000 cubic feet. The laws of the subdivision of the electric current were discussed, and their application to the system of incandescent lighting adopted by Swan, and by Lane-Fox and Edison was clearly shown. With the Bürgin machine, then in use, giving at 1620 revolutions a minute an electromotive force of 160 volts, and a current of 24 webers through an external resistance of about 7 ohms, it was shown that 24 rows of two Swan lamps in series or 48 lamps could be lit up: each lamp being of 80 ohms resistance, and giving a 48 candle-power light. If the resistance of each lamp be 40 instead of 80 ohms, then double the number of lamps might be taken in series, giving about 100 lamps from the machine.

With the Brush machine at least 140 lamps might be lit up in 10 parallel rows of 14 lamps in series. The early attempts of King, and Staite, and Konn to light by incandescence were then explained, and experiments made to illustrate the phenomena seen in high vacua, such as are necessary to enable Mr. Swan and Mr. Lane Fox to preserve their carbons from wasting when rendered incandescent by means of the electric current.

The room was well lighted by means of 20 Swan lamps, each giving a pleasant and steady light of about 40 or 50 candle-power, the lamps being arranged in 10 rows of two in series. Two table-lamps were placed on the lecture-table, which could be put out separately or made to glow at pleasure, and these lamps could be lifted off their stands and others put in their places without disturbing other lights which were arranged in multiple arc and worked from the same dynamo-machine.

THE FRENCH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE AT ALGIERS[1]

II.

Algiers, April 17

On Friday afternoon various papers on local subjects were read to a general audience in the *foyer* of the theatre. They related to the geology, geography, and demography of Algeria, but the most interesting paper was by our Consul-General, Col. Playfair, on a visit to the country of the Kroumirs—interesting not only because the aggressions of this tribe have led to the present complications in Tunis, which will probably end in war, but also because Col. Playfair and Lord Kingston are the only Europeans who have visited their country. They inhabit the district near Le Calle, that is to say, the northern portion of the boundary between Algeria and Tunis, and they only nominally acknowledge the suzerainty of the Bey of Tunis.

On Friday evening a discourse was delivered in the theatre "On Paludisme from a Surgical Point of View." It was of such a very technical character that many members of the Association did not attend. In fact the Congress is to a great extent medical. While the Physical and Botanical Sections are positively languishing for want of papers, and will probably come to a premature ending on Monday, the papers waiting to be read before the Medical Section fill two pages of yesterday's programme.

More activity was manifested in the sectional work on the second day of the Congress; the papers in most of the sections were more numerous and the audiences larger. The physical section is the most neglected of all. Long after the proper time of commencement the president had not made his appearance, and at length Mr. Siemens, the only honorary vice-president, was requested to take the chair. Of the four papers read three were by Englishmen, and on the first day of meeting one paper alone was read by a Dutchman. Pure physics in France is unfortunately quite unrepresented at the Congress. In the Chemical Section M. Baunhauer read a paper "On the Crystallisation of the Diamond," and M. de Foreland "On a New Apparatus for Gas Analysis." There were several good papers on meteorological subjects. Only three papers were read in the Geological Section, the most important of these by M. Villanova, "On the Unification of Geological Nomenclature." The Anthropological Section was well attended, and papers of considerable local interest were read. The Sections of Geography and Political Economy mainly discussed the Sahara—on the one hand its physical geography, and on the other its colonisation.

In the Agricultural Exhibition one of the most interesting machines is the solar engine, the boiler of which is placed in the axis of a mirror 14 feet in diameter, and formed of three portions of hollow truncated cones, so as to get a close approximation to the parabola. When the sun shines a pressure of from three to four atmospheres is produced in the boiler, and a force of one-horse power is produced through the intervention of an

[1] Continued from p. 583.